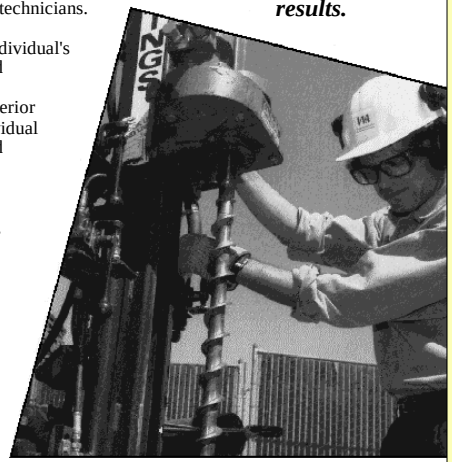
Expertise in Geology, Engineering and Environmental Science

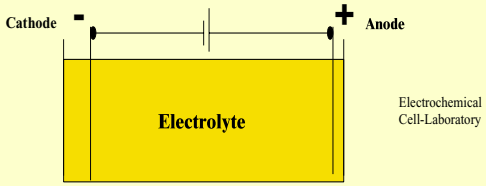
Weiss Associates is skilled and experienced in areas essential to Environmental Industry geoscience problem solving. Staff members include geologists; hydrogeologists; civil, environmental, chemical and mechanical engineers; environmental scientists; regulatory specialists and technicians.

At Weiss Associates, outstanding people produce outstanding results.

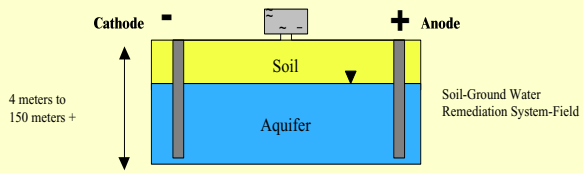
We recognize that each individual's intelligence, creativity and perseverance are essential ingredients to create a superior work product. These individual human traits are cultivated and encouraged at WA.

WA's staff uses the most advanced field equipment, techniques and computer technology. Quality is maintained through communication with staff and careful recruiting, training and supervision. The result is work that consistently satisfies or exceeds the require-ments of our clients and local, state and federal regulators.





Electrochemical Cell-Laboratory



Soil-Ground Water Remediation System-Field

Weiss Associates
P2-Soil Remediation, Inc.

ELECTROCHEMICAL REMEDIATION OF PECONIC RIVER SEDIMENTS

presentation to
Brookhaven National Laboratory
December 12, 2000

Prepared by

Joe L. Iovenitti—Weiss Associates

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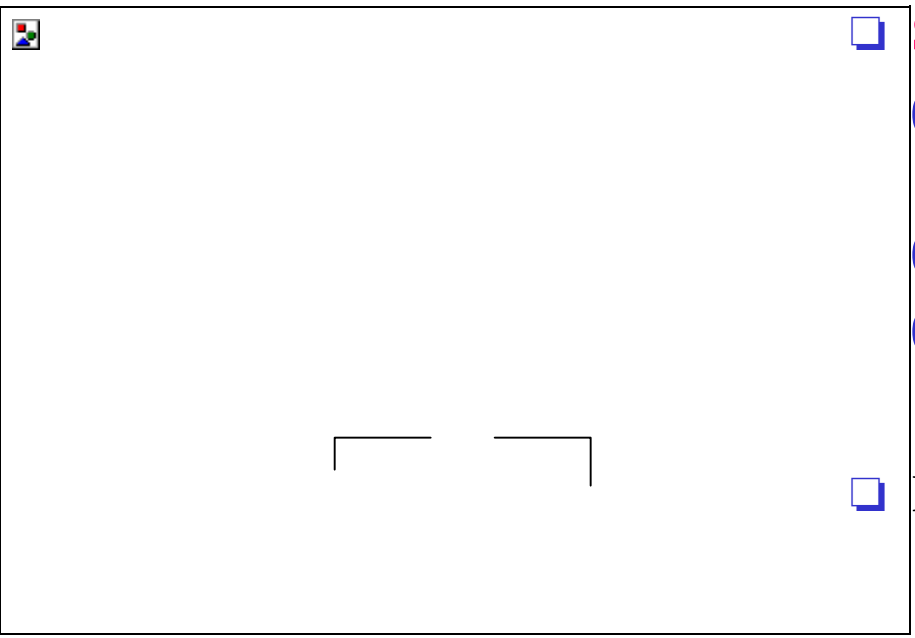
STAKEHOLDER-IDENTIFIED ISSUES

- Third Party Confirmation of Patented Technologies or Claims
  - ElectroChemical Remediation Technologies (ECRTs) patented in US and Europe
    - US Patent Nos. 5,738,778 and 5,595,644
    - US references for *in-situ* organic destruction **(ECGO**) available
    - European scientific/academic reference also available
      - ✔ For references contact J. L. Iovenitti at jli@weiss.com
- Minimize Impact/Damage to Wetlands & Adjacent Areas
  - *In-Situ* Approach
  - Impact/Damage relatively minimal

STAKEHOLDER-IDENTIFIED ISSUES

- Minimize or Eliminate Re-Suspension or Recontamination of Sediments Downstream
  - ECRTs are applied *in-situ*
  - Re-suspension or recontamination is virtually eliminated
- Technology Applicability to Peconic River Sediments
  - Subject of this presentation

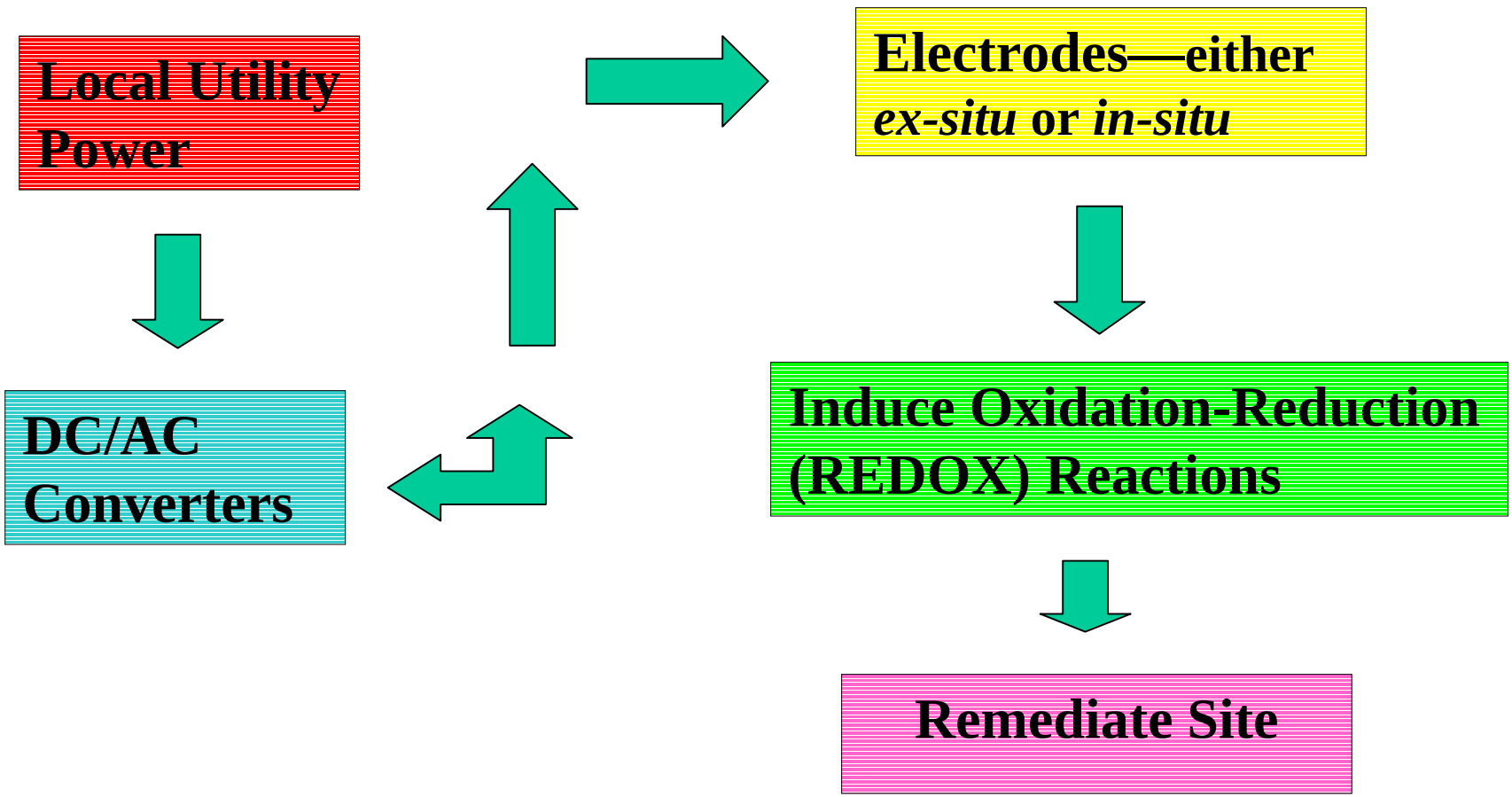
OVERVIEW



- **SHOW** ECRTs capabilities to
  - (1) mineralize organics to their inorganic components
  - (2) enhance the mobilization of metals
  - (3) treat dissolved phase contaminants
- ElectroChemical Remediation can be fast
  - ✔ **168 lbs. of Hg Plated to Electrodes in 26 days**

Soil -Ground Water System = ElectroChemical Cell

PROCESS FLOW—ELECTRICITY



ECRT

- Proven European Technology on Commercial Basis, Considered the Next Generation in Electro-Kinetics
- Major Mechanisms
  1. Induced REDOX Reactions
     - Destruction of organics (**ECGO**)
     - Enhanced mobilization of metals and radionuclides that behave as metals (**IC**)
       - ✔ Mechanisms of Electro-Osmosis, Electro-Migration, and Electro-Phoresis occur at formation scale
  2. Believe Electrolysis Is Occurring at Pore Scale

INDUCED REDOX REACTIONS

- How Do They Occur?
  - Electrodes are placed in the sediment where a low voltage and low amperage coupled DC/AC field is imposed
    - An Induced Polarization (IP) field is created ➡ the soil acts as a capacitor ➡ discharges of electricity occur
      - ✔ **In the electrical discharge, REDOX reactions take place**

INDUCED REDOX REACTIONS

- Where Do They Occur?
  - In the soil under *Ex-Situ* or *In-Situ* conditions
    - Reactions take longer in gravel than fine sand, fine sand takes longer than clay
      - ✔ **Reaction rate is inversely proportional to grain size**
  - At the Pore Scale
    - One theory is that these reactions occur at any and all interfaces within the soil-water-contaminant system

No pumping or addition of chemicals during ECGO or IC.

ECGO FIELD REMEDIATION RESULTS

Selected ECGO Organic Field Project Case Histories, Initial and (Post-Treatment) Concentrations												
Site	TPH[1]	EOX[2]	BTEX[3]	PAH[4]	PAH (TVO)[6]	PCB[7]	MNT[8]	DNT[9]	Duration of Remediation (days)	Surface Area (square meters)	Depth (m)	Treated Soil (metric tons)
	←——————————(mg/kg)——————————→											
World War II Ammunition Factory, Lower Saxony	1,800 (270)	0.71 (0)	51 (<0.1)	68 (2.8)	16 (2.8)	-	24,200 (5,300)	4,500 (570)	30	160	8	1,700
Manufactured Gas Plant Area A, Schieswig-Holstein	-	-	-	3,800 (65.3)	1,344 (16.1)	-	-	-	75	875	1.2	1,600
MGP Area B, Schleswig-Holstein	-	-	-	338 (26.3)	132.1 (6.1)	-	-	-	80	3,500	1.4	3,500
Coal Mine, Ruhr	-	-	-	782 (33.9)	-	0.45 (<0.01)	-	-	273	750	1	1,400
Enns, Austria	-	-	-	1, 354 (55)		-	-	-	70	NA	NA	500

1–Total Petroleum Hydrocarbons

2–Total extractable Halogens in organic bonding (e.g., PCE, TCE, VC, PCP, etc.)

3–Benzene, Toluene, Ethylbenzene, Xylene

4–Polyaromatic Hydrocarbons

6–Fluoranthene, Benzo(a)pyrene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Benzo (b)fluoranthene, Benzo(ghi)pe

7–Polychlorobiphenyls

8–Sum of Nitrotoluenes

9–Sum of Dinitrotoluenes

NA–Not Available

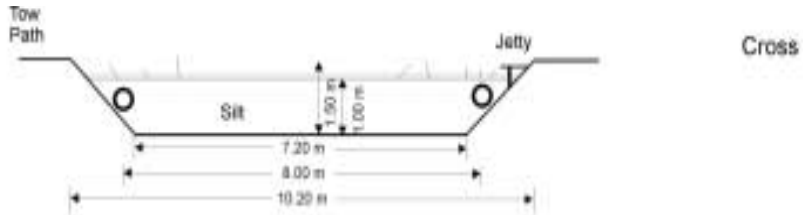
IC FIELD & LABORATORY RESULTS

Initial and (Post Remediation) Concentrations in mg/kg												
Site	**Hg**	**As**	**Pb**	**Cd**	**Cr**	**Cu**	**Ni**	**Zn**	**Time (days)**	**Area (m^2)**	**Depth (m)**	**Soil (mT)**
Detonator Factory	243 (5.7)	-	-	-	-	-	-	-	26[a]	200	1.1	400
Sludge lagoons of a Rolling Mill in Finow	-	92 (30)	400 (100)	0.5 (0)	49 (6.1)	48,000 (4,000)	0.53 (0.11)	4,800 (170)	30	210	1.2	450
Steel Mill in Luebeck	-	34 (28)	400 (200)	-	-	330 (150)	-	1,200 (610)	10	NA	NA	NA
Hamburg Harbor Sludge	0.5 (<0.1)	13 (2.3)	173 (38)	10 (2)	72 (16)	143 (12)	0.056 (0.005)	901 (51)	14	NA	NA	NA

[a] Actual Active Remediation Time = 15 days

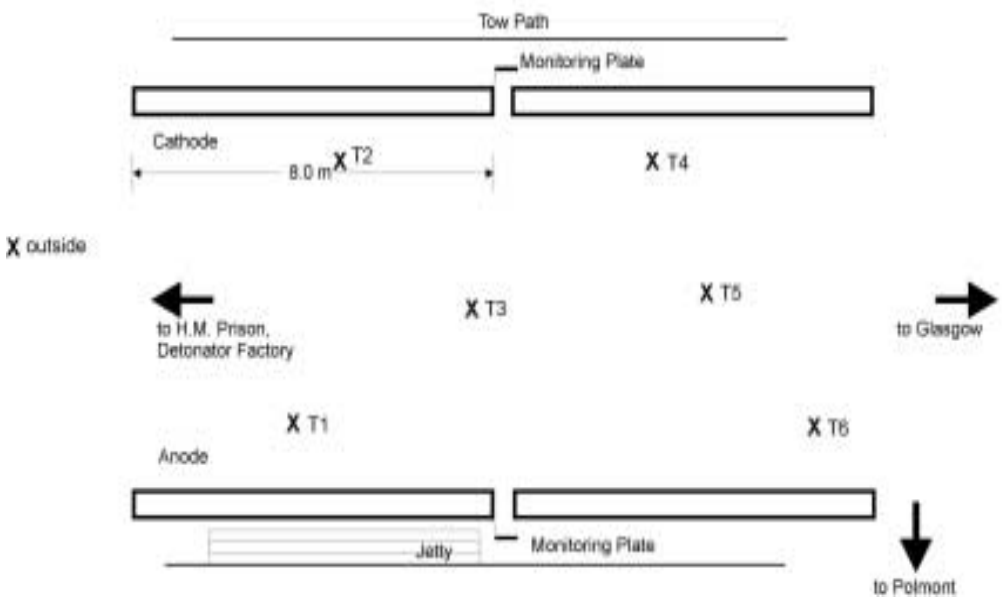
NA—Not Available Because These Were Laboratory Tests

UNION CANAL, SCOTLAND



Cross Section

Plan View

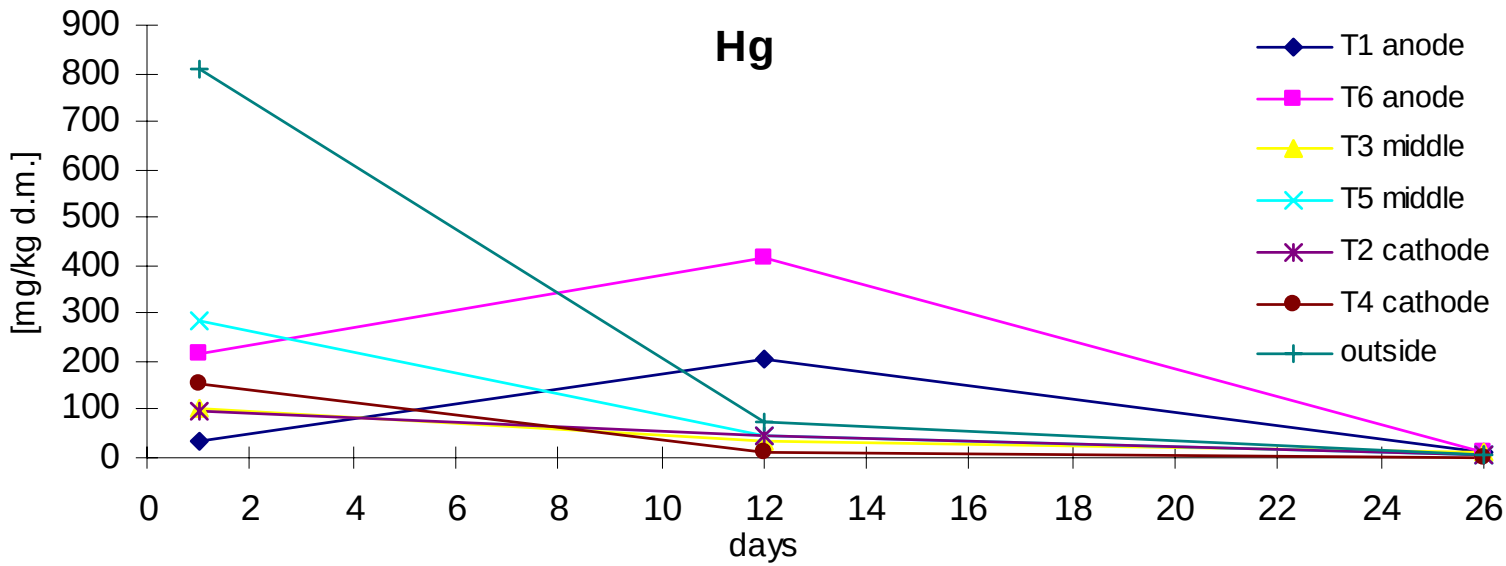


Water TDS: ~ 3.5 g/l mainly sodium chloride
Main Pollutant: Mercury including organic Mercury Fulminate
Electrodes: Steel pipes 192 mm OD each 8 m long
Electric input: 140 Volt, 40 Amps

UNION CANAL, SCOTLAND

Results
(all figures in mg Hg/kg dm)

Days	1	12	26
T1 anode	33	204	11
T6 anode	218	417	9
T3 middle	102	36	11
T5 middle	282	48	6
T2 cathode	98	45	4
T4 cathode	156	9	0,7
Outside	809	73	4



Problems encountered: Strong corrosion of steel anodes. Replacement by copper sheet electrodes with "satisfactory" performance as to the precipitation of Mercury and other metals, in particular As, Cd, Pb.

Application to Peconic River Contaminated Sediments

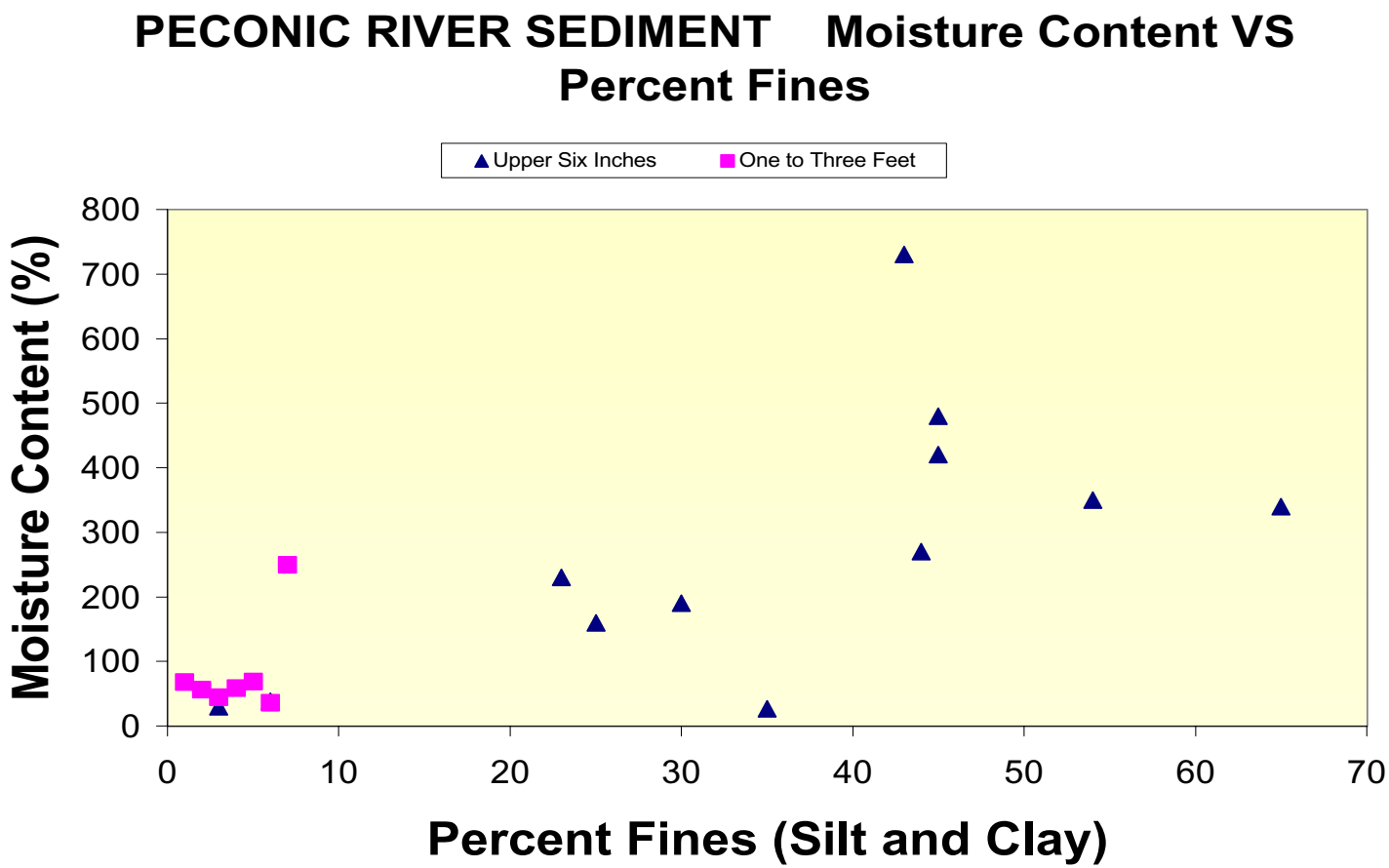
TECHNICAL ADVANTAGES

- Flexible (Tactical) Deployment
  - Vertically and horizontally
- Minor to Minimal Environmental Impacts
- No Modifications to the Ecosystem Required
- Effective Remediation of Metals and Radionuclides that Behave as Metals
- Effective Against Organics
- Rapid Remediation - On Order of Weeks to Months
- Potential for Future “Remediation-On-Demand”

SITE CONDITIONS

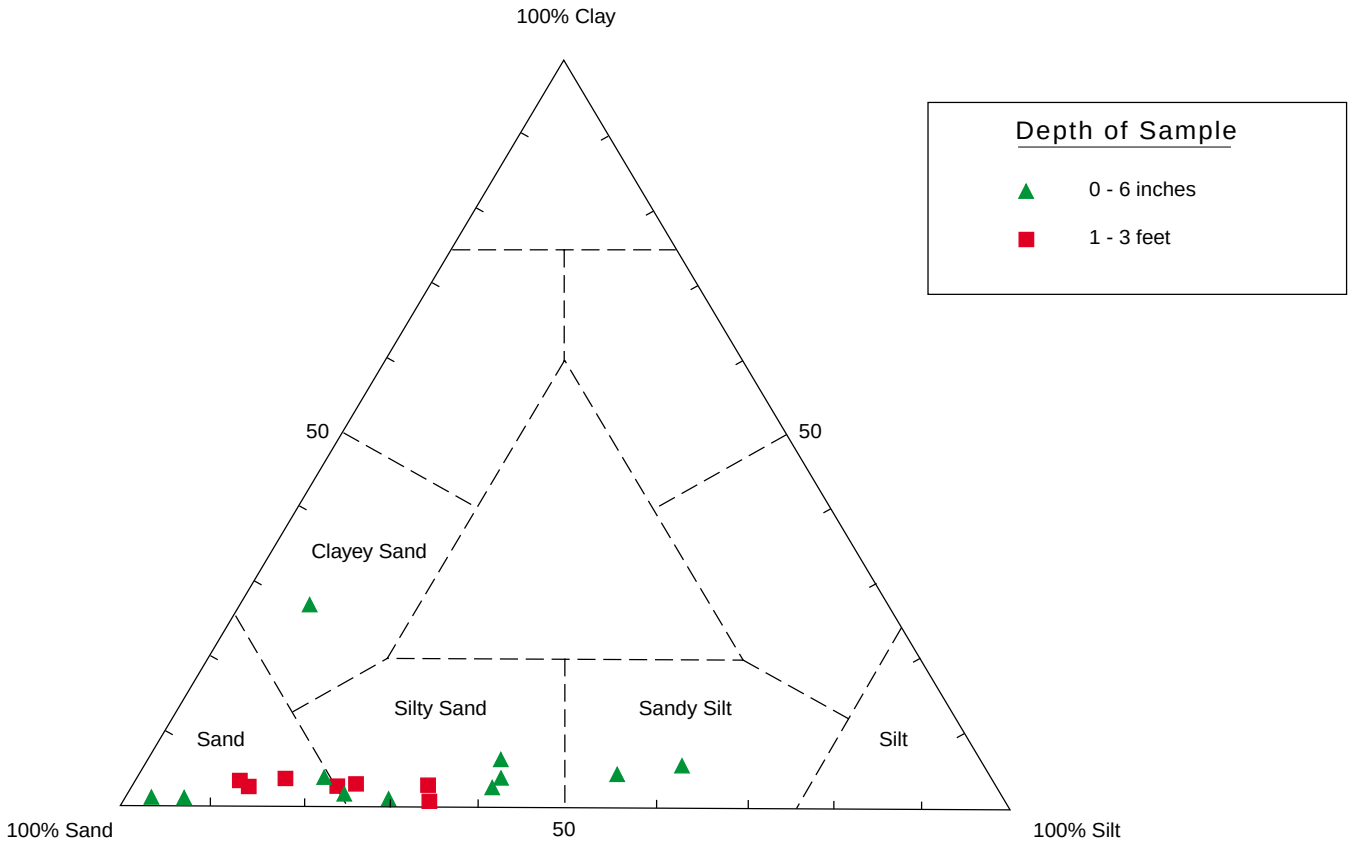
- Favorable for ECRT Remediation
  - Heavy metal (Hg, Ag, and Cu) contamination in upper six inches
    - Metals readily migrated to electrodes using IC
  - pH from 5.4 to 7.0 in upper six inches, 6.3 - 6.6 at one to three-ft
  - Silty sand and sandy silt predominates in upper six inches, sandier at depth; comparable to successful ERCT metal project
  - Generally higher water content in upper six inches
  - Electrode installation by hand or low-impact methods is feasible

PECONIC RIVER SEDIMENTS



PECONIC RIVER SEDIMENTS

Grain Size Analysis

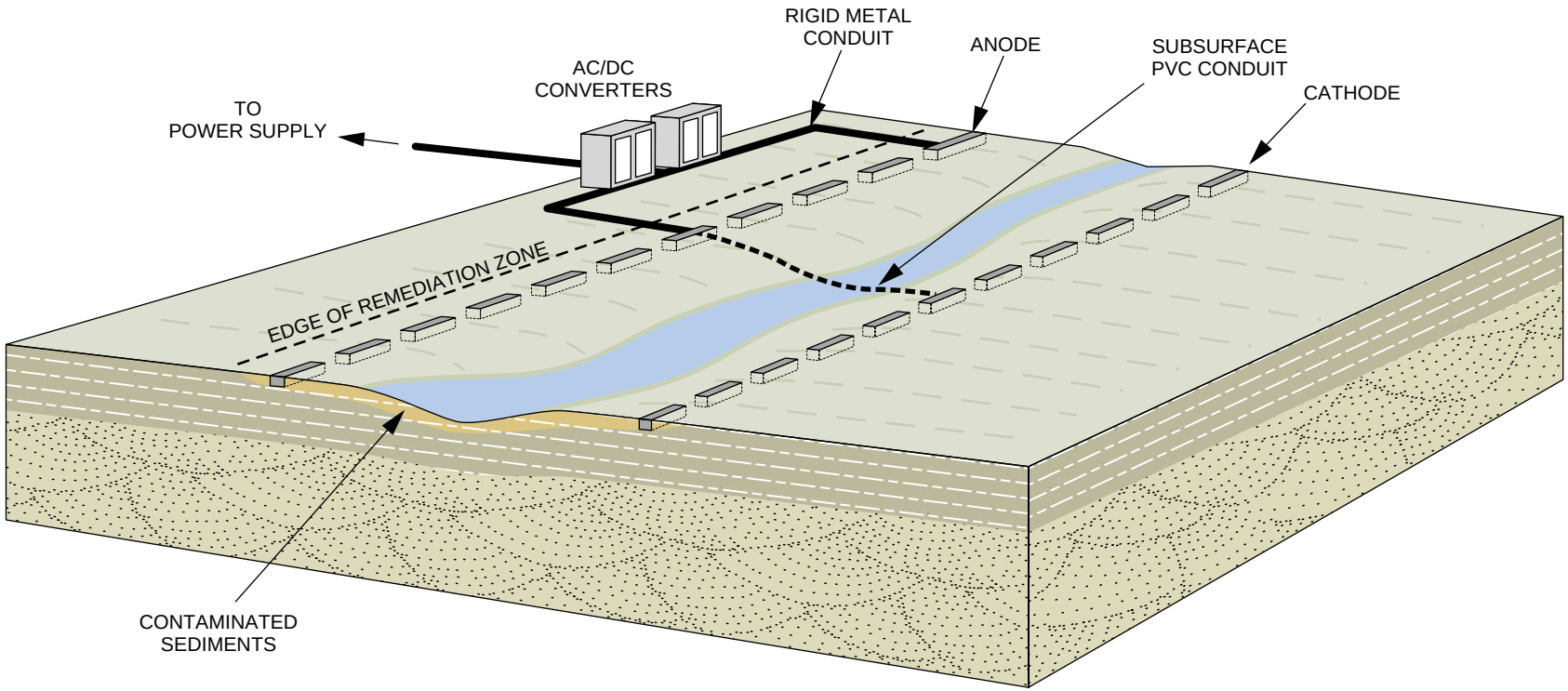


PECONIC RIVER REMEDIATION

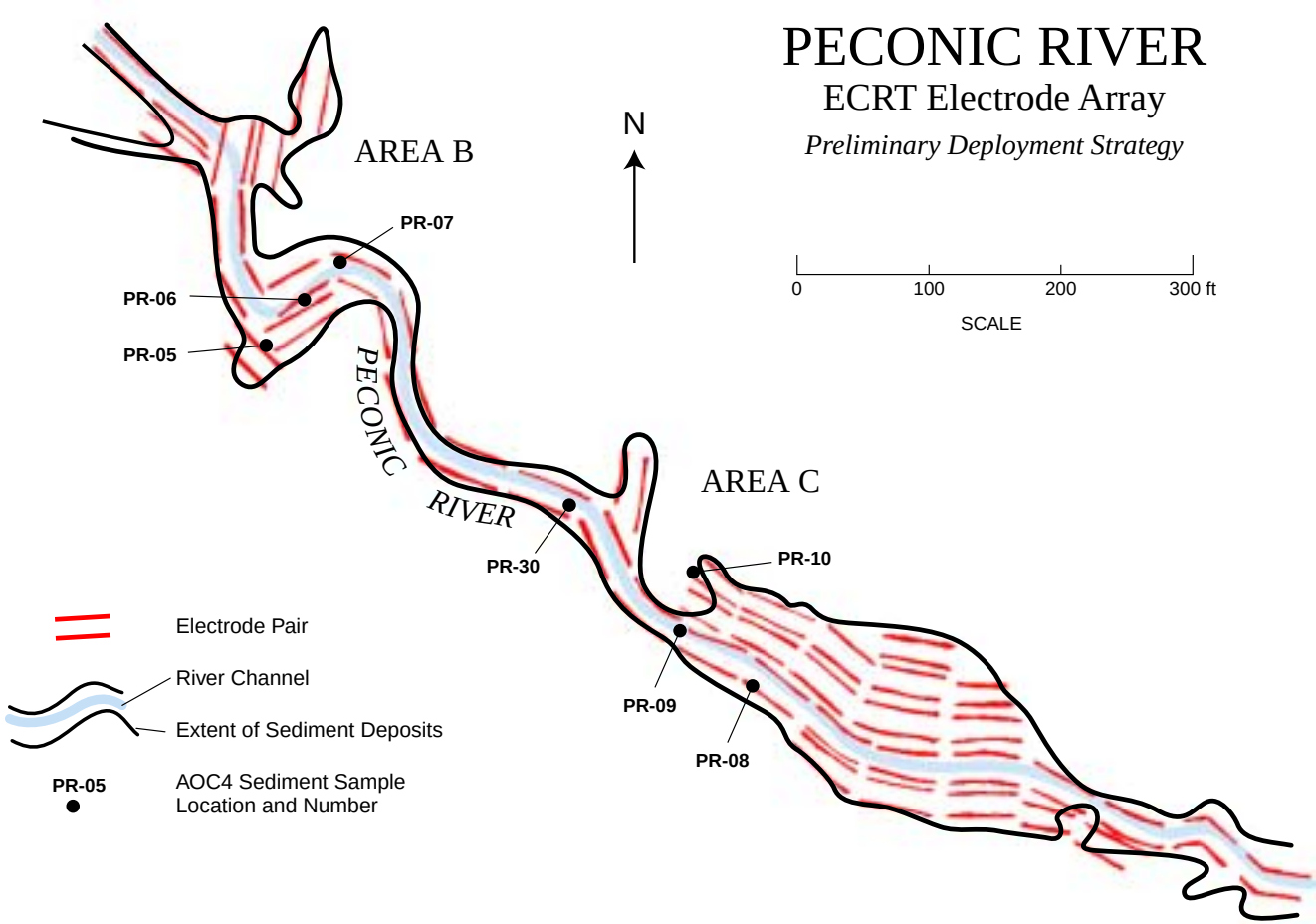
- Before Remediation

PECONIC RIVER REMEDIATION

- Typical Deployment



PECONIC RIVER REMEDIATION



PECONIC RIVER REMEDIATION

- **Post-Remediation**
  - River restored to original conditions in relatively short order
    - Due to minimal disturbance by technology deployment

PECONIC RIVER REMEDIATION

- Technical Considerations & Limitations
  - *Extent of Contamination*: Costing based on 448,200 ft^2 x 0.5 ft, per BNL RI/FS
    - Additional site characterization assumed necessary
  - *Water Depth*: Alternating wet and dry periods
    - Irrigation can be employed for dry conditions
  - *Freezing*: ECRT not effective in frozen ground
  - *Pilot Test*: Recommended prior to full scale implementation

PECONIC RIVER REMEDIATION

- Health & Safety Considerations
  - *Fish, Reptiles, Birds, Mammals, & Humans:* No adverse effect unless in direct contact with electrodes
    - Direct electrode contact = not lethal
    - Electrical conditions (voltage, current density) too low to affect wildlife
  - *Worms, Insects, & Soil Microbes:* No adverse affects unless in direct contact with electrodes
    - Mortality from direct contact = unknown to us
  - *Magnetic Effects*: Unknown but estimated to be significantly less than conventional power lines

PECONIC RIVER REMEDIATION

- Unknown Site Conditions
  - Soil resistance during different seasons
    - Moisture content variation with time is useful
  - Detailed contaminant distribution with depth
    - If depth increases, cost per cubic yard (yd^3) decreases
    - If depth increases to about 2 - 3 feet, additional cost for remediation is negligible relative to cost for 6-inch remediation

FIELD DEPLOYMENT

- Urban Luxemburg
  - Technology deployment had no interference with ongoing city activity

Note DC/AC converters (white boxes) and distribution panel (orange boxes)

SUMMARY

- ISO 9001 Certified & Insurable
- Destroys Organics in Place (**ECGO**)
- Significantly Enhances Mobilization of Metals (**IC**)
- Remediation Time = Typically Months
- Upland General Preliminary Engineering Cost Estimate (PECE) = **$100/yd^3 for 3,000 yd^3** to **<$20/yd^3 for 100,000 yd^3**
- Aquatic General PECE = **$120/yd^3 for 3,000 yd^3** to **<$30/yd^3 for 100,000 yd^3**
- *Ex-Situ* and *In-Situ* Applications Possible